November 1974

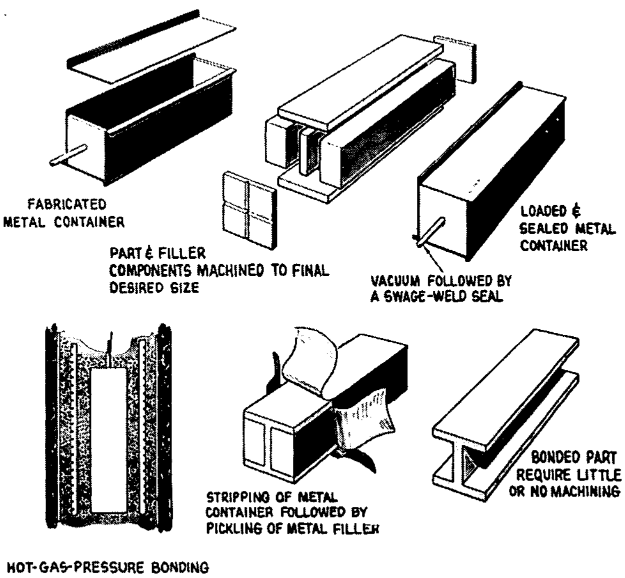
B74-10124

NASA TECH BRIEF

Lewis Research Center

Fabrication of Complex Structures or Assemblies by Hot Isostatic Pressure (HIP) Welding

GAS-PRESSURE BONDING PROCESS



Hot isostatic pressure (HIP) welding is an effective method for fabricating complex structures or assemblies such as alternator rotors, regeneratively-cooled rocket-motor thrust chambers, and jet engine turbine blades. It can be applied to the fabrication of many assemblies which require that component parts be welded together along complex interfaces.

HIP welding (which is also known as gas-pressure bonding) is an efficient solid-state welding process performed in a high-pressure autoclave in which the welding force is applied by inert gas at elevated temperatures. The isostatic nature of this process allows components of multiple sizes and shapes to be welded into a single unit. HIP welding techniques have been developed which achieve 100% base metal strength across the joints. Small amounts of misfit between components can be accommodated by utilizing the applied temperature and pressure to creep-form mating components into full contact during the welding cycle.

In the HIP welding process, the components to be welded are fabricated or machined to final size, cleaned, and assembled into an expendable container (canned). This container, when evacuated, serves to enclose the assembly in a pressure-tight envelope. Alternately, the components can be sealed by fusion welding at the joint periphery to produce a pressure-tight evacuated envelope. Filler metal is often employed to fill open areas and thus prevent collapse of thin-wall sections. The evacuated sealed assembly is then heated to an elevated temperature in an autoclave containing an inert gas at high pressures up to 173×10^7 MN/m^2 (150,000 psi) but usually between 3.5×10^7 and 21×10^7 MN/m^2 (5000 and 30,000 psi). Pressure is applied uniformly to all exterior surfaces (through the container, if one is used) and forces all of the mating surfaces into intimate contact. The mating surfaces are held under pressure at about one-half to three-quarters of the melting temperature for a sufficient time, normally a few hours, to permit solid-state welding between the components.

The only deformation (plastic flow) occurring during bonding is the amount necessary to bring the components into intimate contact. The dimensional tolerances achieved in the weldment are therefore chiefly governed by the dimensional tolerance that is specified for each individual component. Because only a small amount of deformation is involved, brittle materials can be welded without adverse effects. In experiments with many systems, the bonds produced by HIP welding under proper conditions have proven to be consistently strong, and the test specimens prepared have displayed satisfactory corrosion resistance and physical properties after HIP welding. In most cases, no trace of the original bond line can be detected by metallographic examination or nondestructive testing.

Some of the advantages of the HIP welding process for joining complex shapes are:

1. Adequate metallurgical bonds can be obtained by this solid-state welding process;
2. Very close dimensional control can be achieved;
3. Many similar or dissimilar materials can be welded together usually in a one-step operation;
4. Components of brittle metals which cannot be joined by conventional techniques can be solid-state welded; and

(continued overleaf)

5. In some cases, fabricating costs can be lower than those for conventional fabrication processes.

Notes:

1. The HIP welding process was originally developed at the Battelle Memorial Institute's Columbus Laboratories in 1955. NASA and the aerospace industry have continued to advance the state-of-the-art of this technology by developing techniques for fabricating aircraft and spacecraft engine components.
2. Further information is available in the following reports:

   NASA CR-72795 (N71-16381), Development of Advanced Fabrication Techniques for Regeneratively Cooled Thrust Chambers by the Gas-Pressure-Bonding Process

   NASA CR-120923 (N74-30574), Development of a Gas Pressure Bonded Four Pole Alternator Rotor

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10124
3. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10124

Patent Status:

NASA has decided not to apply for a patent.

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under contract to
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(LEW-11490)